Assimilation of data from AIRS for improved numerical weather prediction

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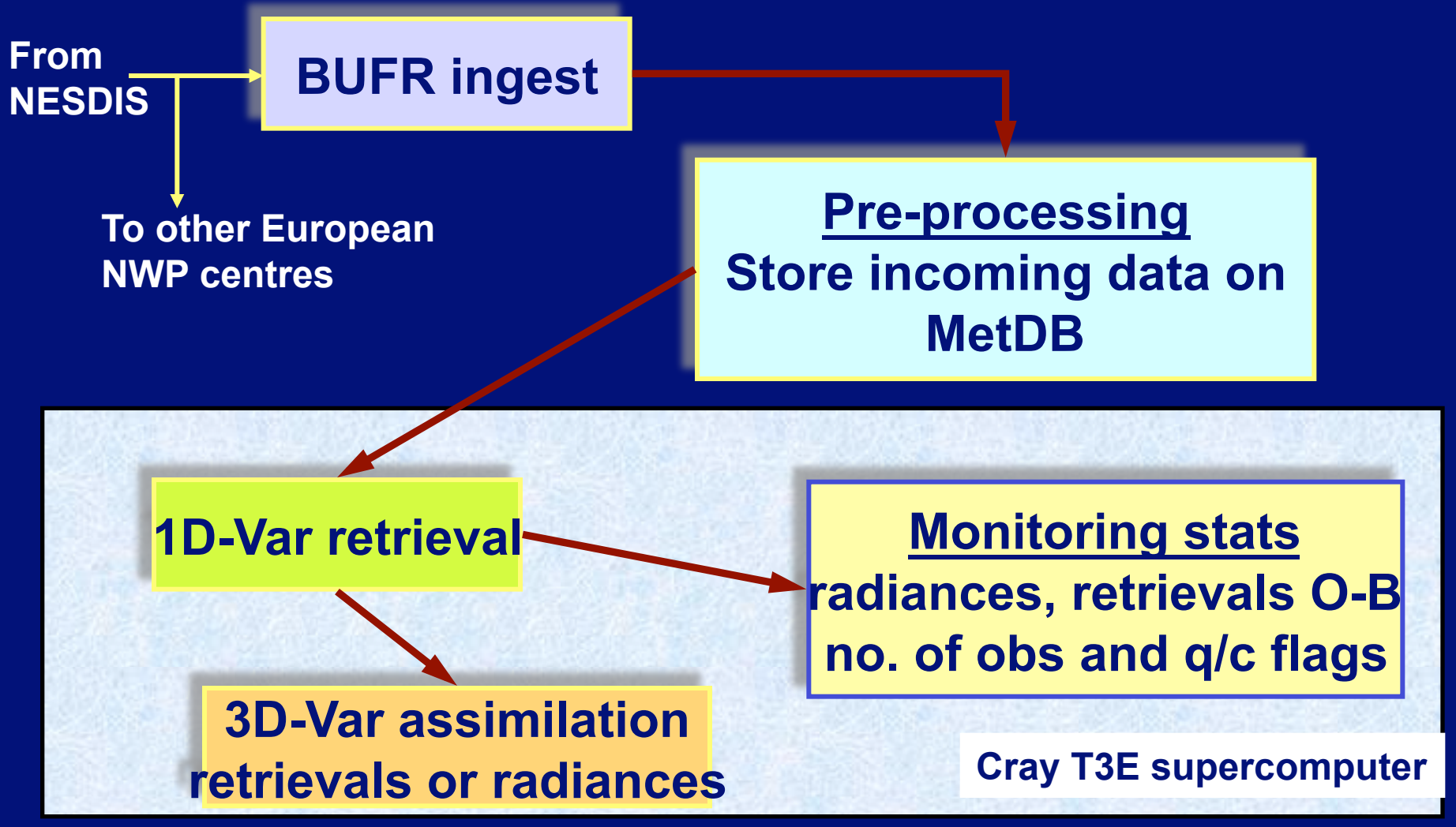
AIRS data processing at the Met Office

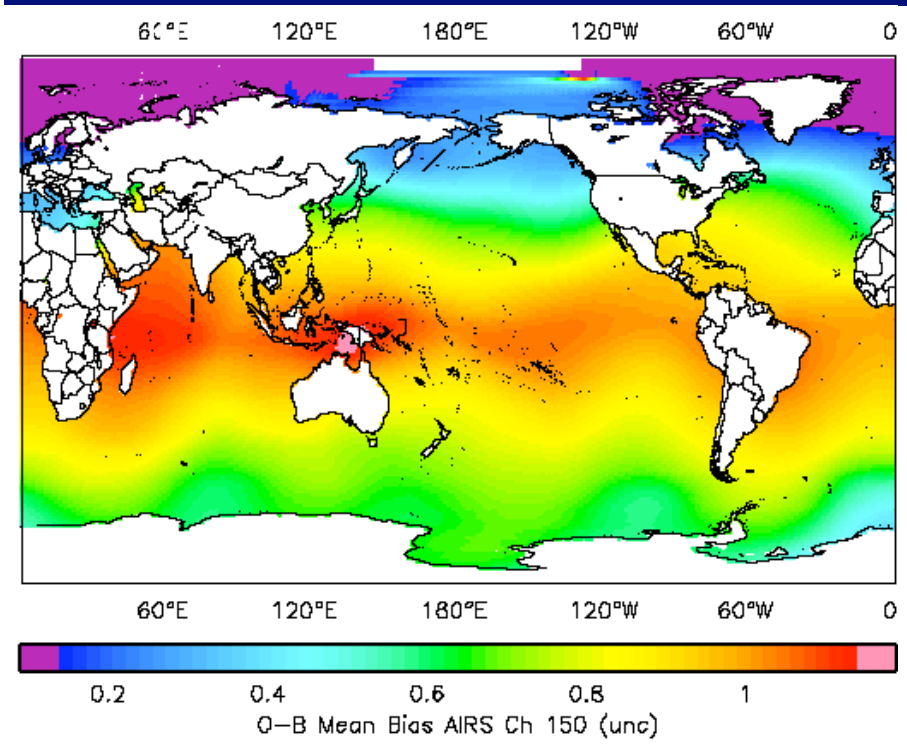


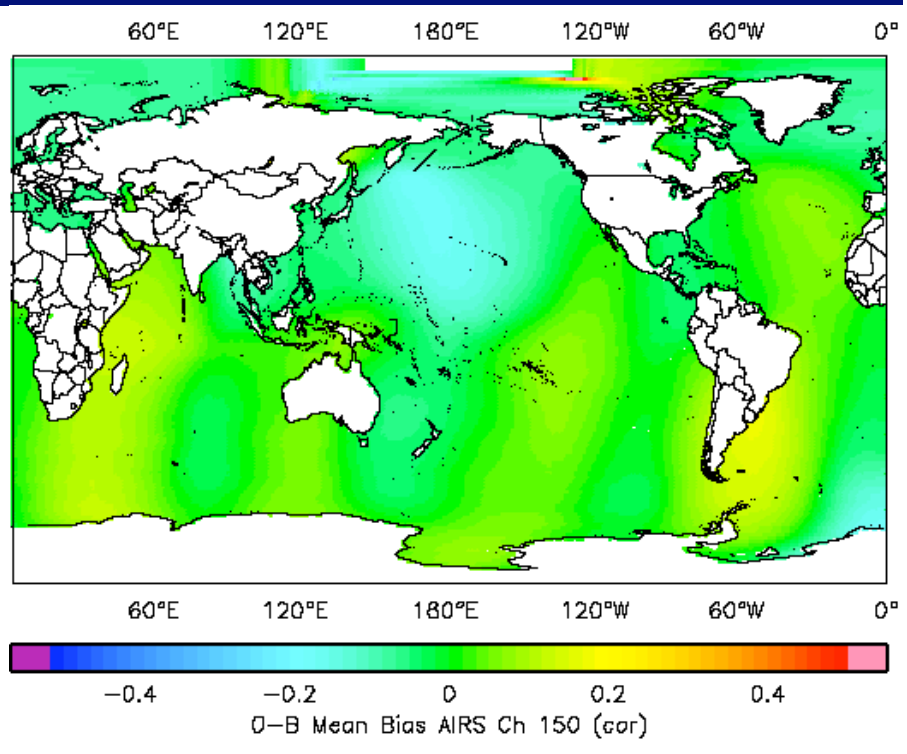
Bias Correction

- Biases vary with scan angle
- Biases vary with “air-mass”
- Biases are channel dependent

- Air-mass bias predictors
  - brightness temperature
  - 200-50 hPa thickness
  - 850-300 hPa thickness

16 January - 15 February 2003, AIRS channel 150 (692.8 cm^{-1} / 14.4





Variational Cloud Detection

(English, Eyre & Smith, 1999)

Attempt to determine the probability of having cloud in the field of view given the observed radiances and the NWP background profile

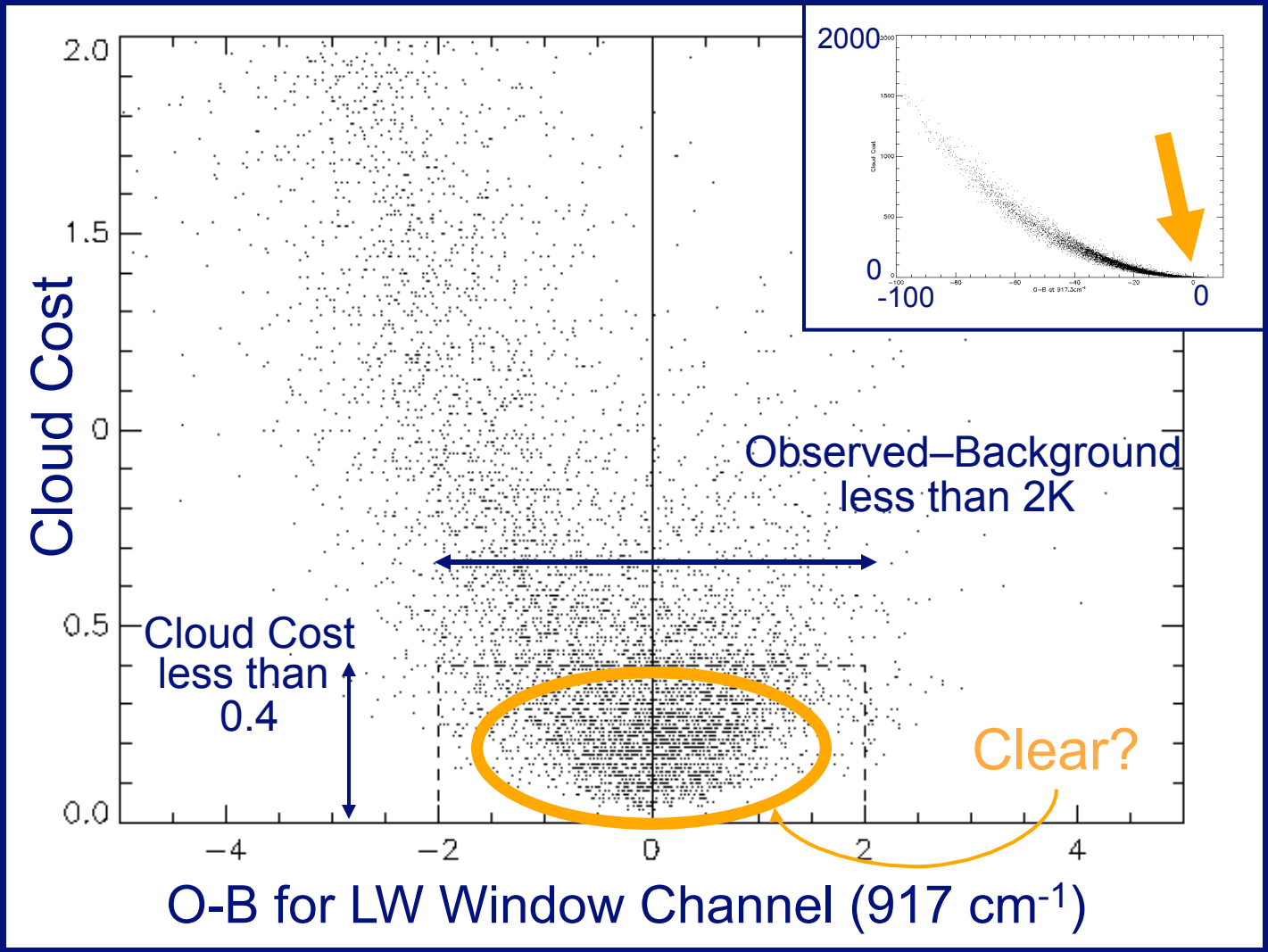
$$J = -\mathrm{Ln}\{P(\mathrm{cloud} \mid \mathbf{y}_{\mathrm{obs}}, \mathbf{x}_{\mathrm{b}})\}$$

$$\simeq -\tfrac{1}{2}(\Delta\mathbf{y})^{\mathrm{T}}\{\mathbf{H}(\mathbf{x}_{\mathrm{b}})^{\mathrm{T}}\mathbf{B}\mathbf{H}(\mathbf{x}_{\mathrm{b}}) + \mathbf{R}\}^{-1}(\Delta\mathbf{y}) + \mathrm{Const.}$$

$$\Delta\mathbf{y} = \mathbf{y}_{\mathrm{obs}} - \mathbf{y}(\mathbf{x}_{\mathrm{b}})$$

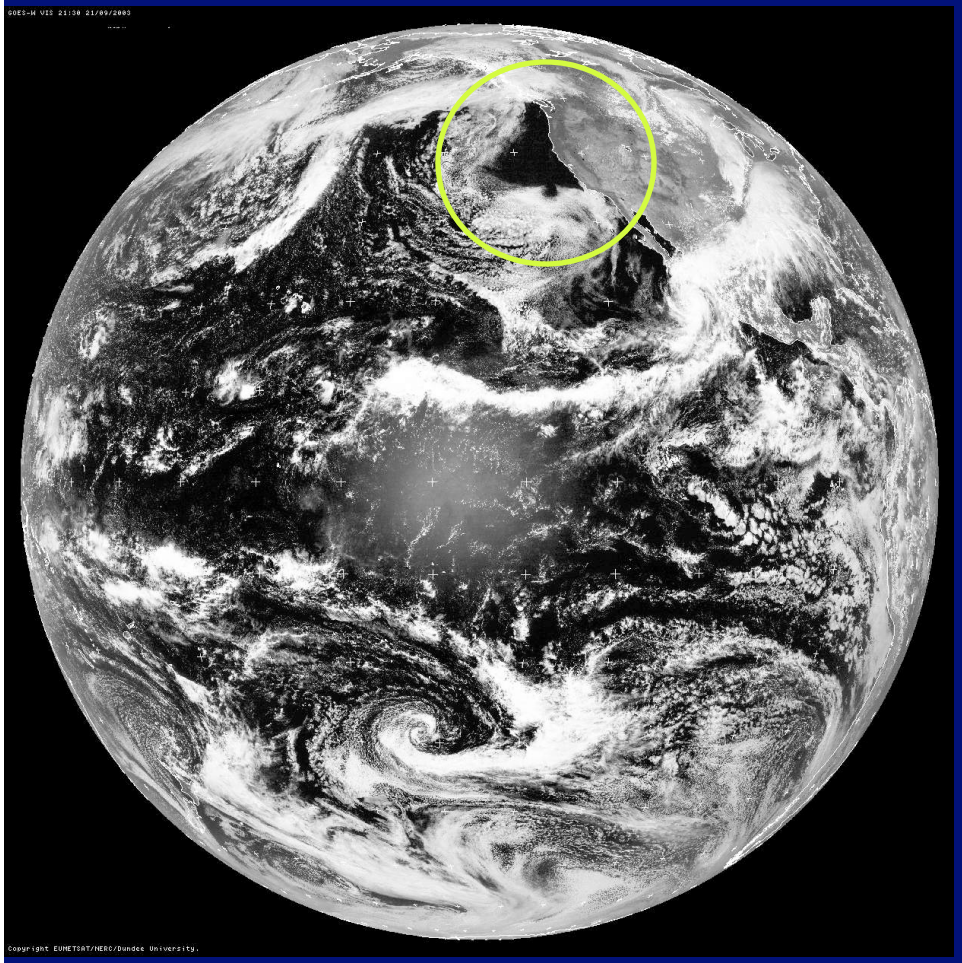
Clouds are flagged when J exceeds a certain threshold

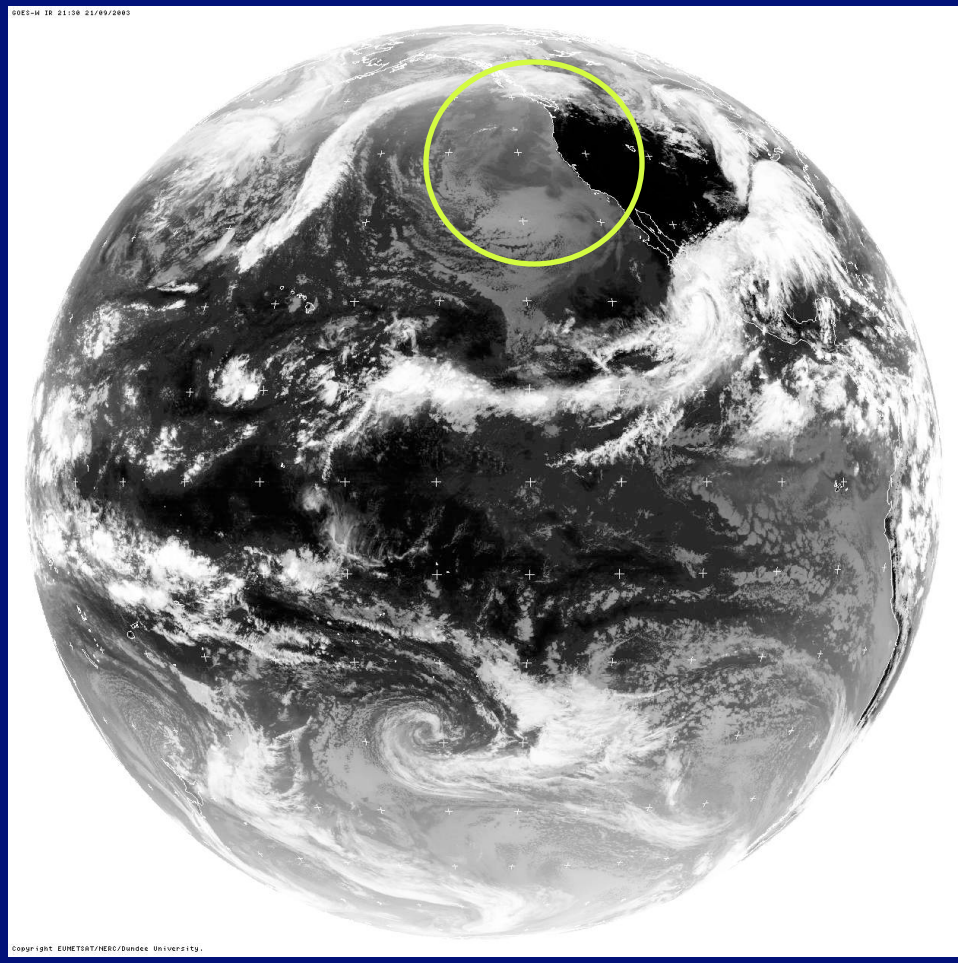
Variational Cloud Detection



Attempt to determine the probability of having cloud in the field of view, given the observed radiances and the NWP background profile

GOES-W Images. 21/9/03 21.30Z





Focus on region of low thin cloud off western USA.

Cloud Detection

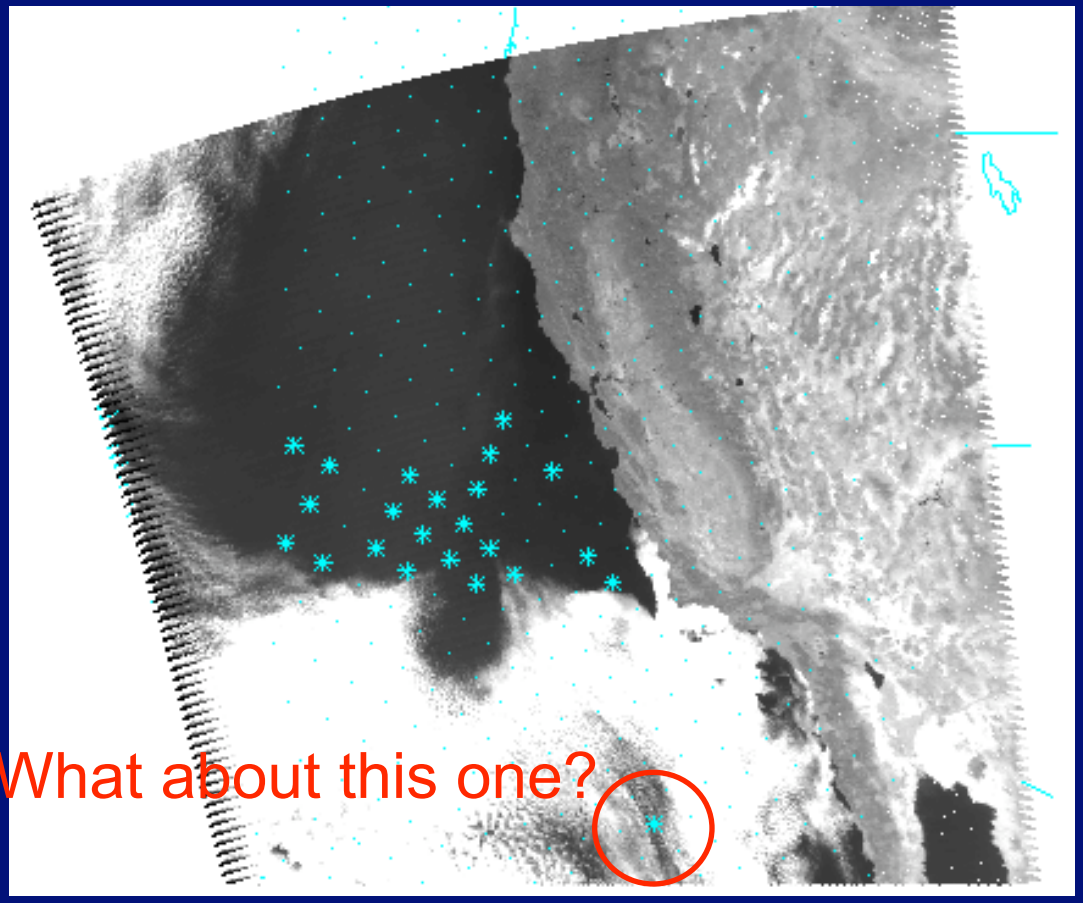
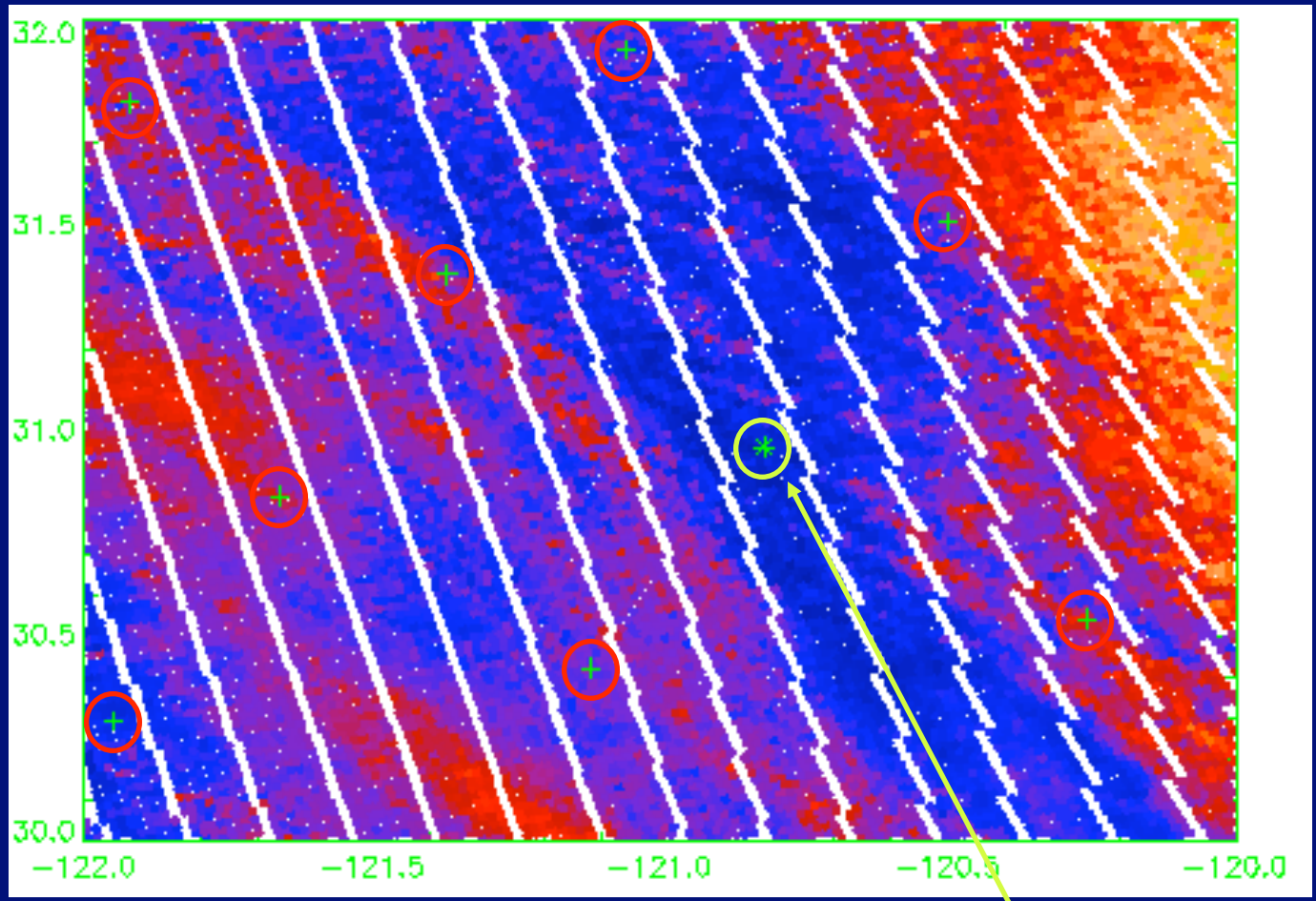


Image is AIRS Visible Imager Channel 4.
21st Sept. 2003 ~21.30Z

*=AIRS “Clear” FOV
. =AIRS “Cloudy” FOV

Cloud Detection

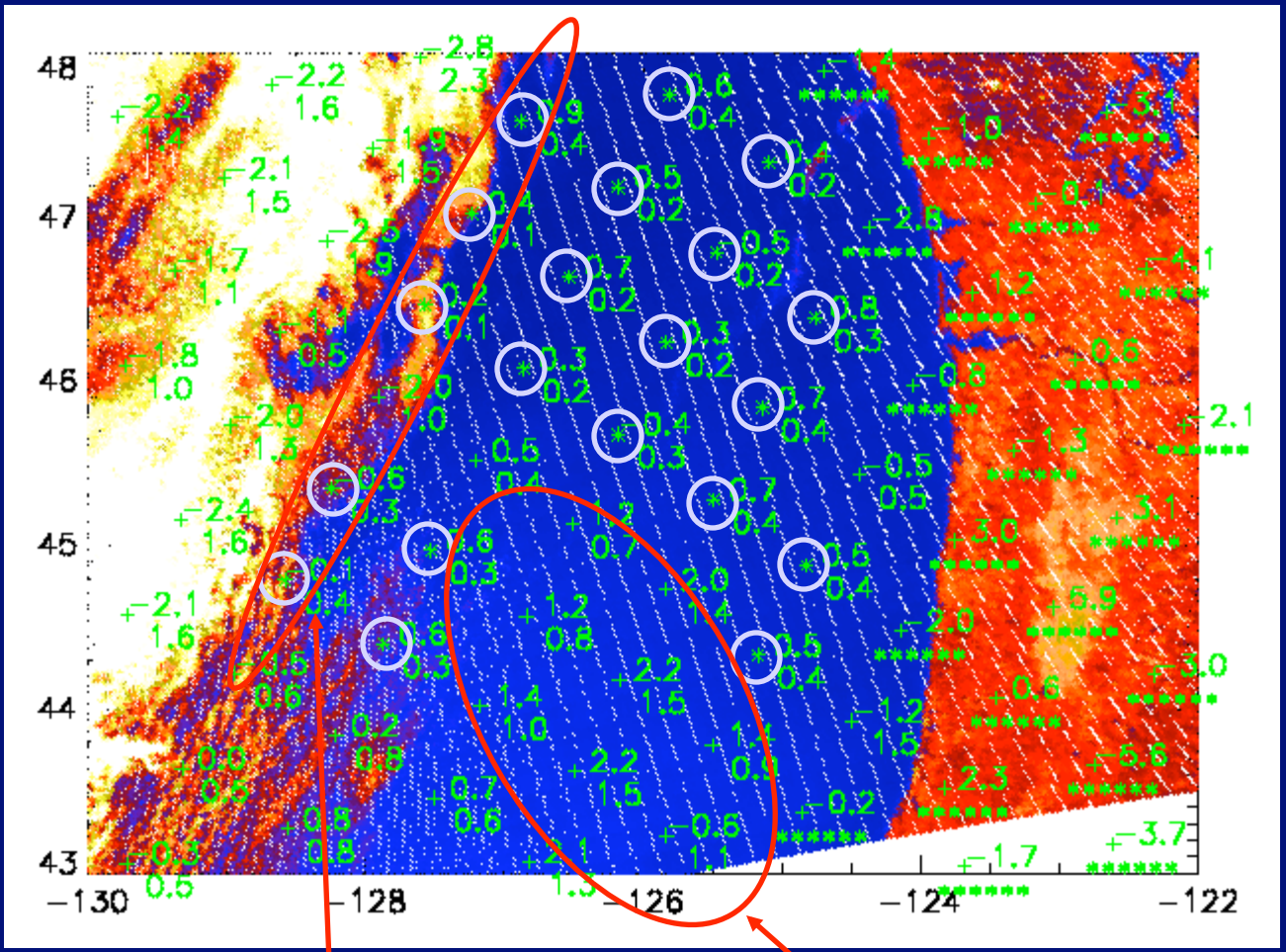


Blue = Low Albedo

Orange = High Albedo

Point from previous page seems to be clear

Off the coast of Washington



Top number is
O-B in LW Window

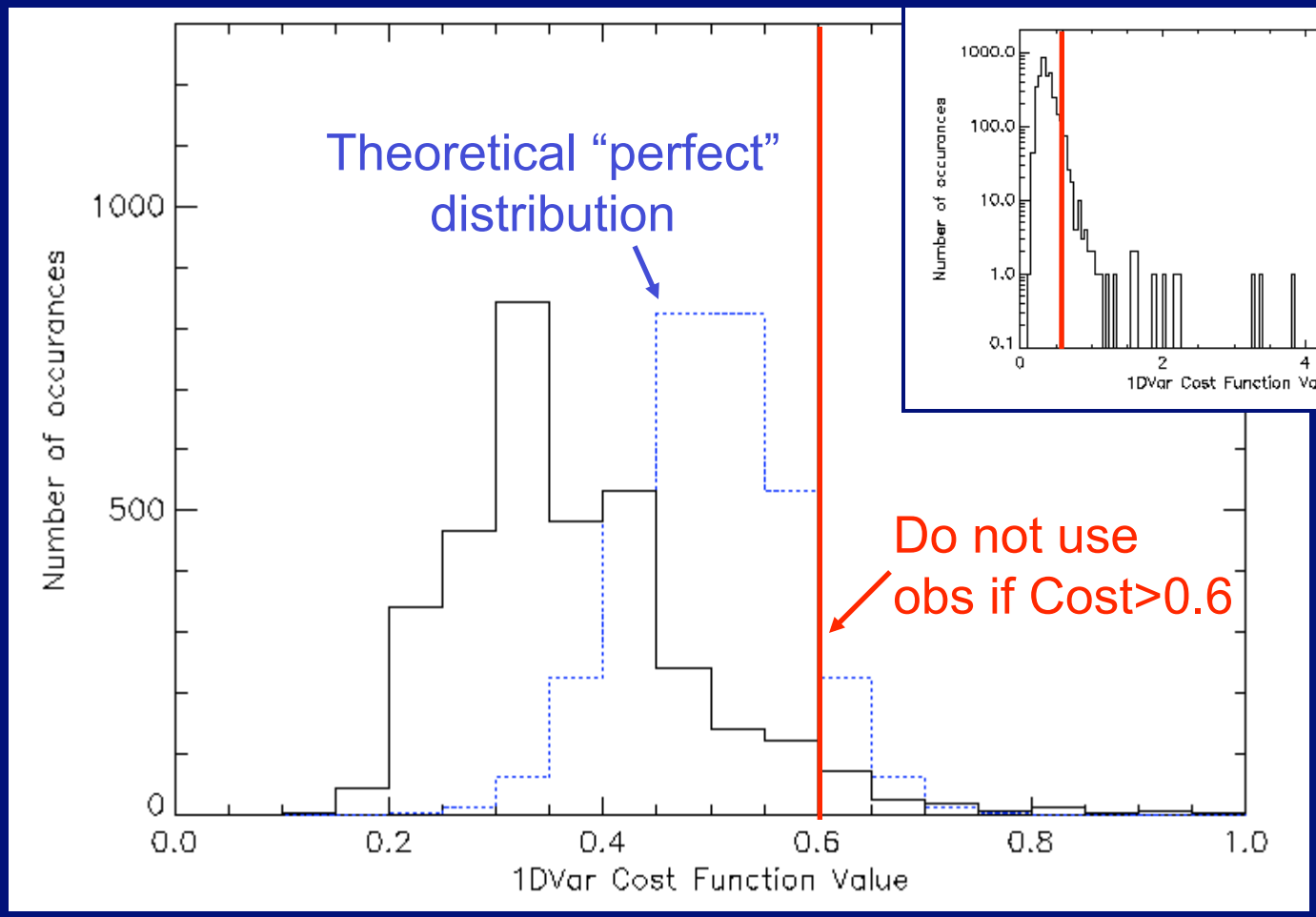
Bottom number is
Cloud Cost

Circled obs are
designated clear

Here there are some erroneous clears on edge of thin, low cloud.

This region has high O-B:
Almost certainly real SST error

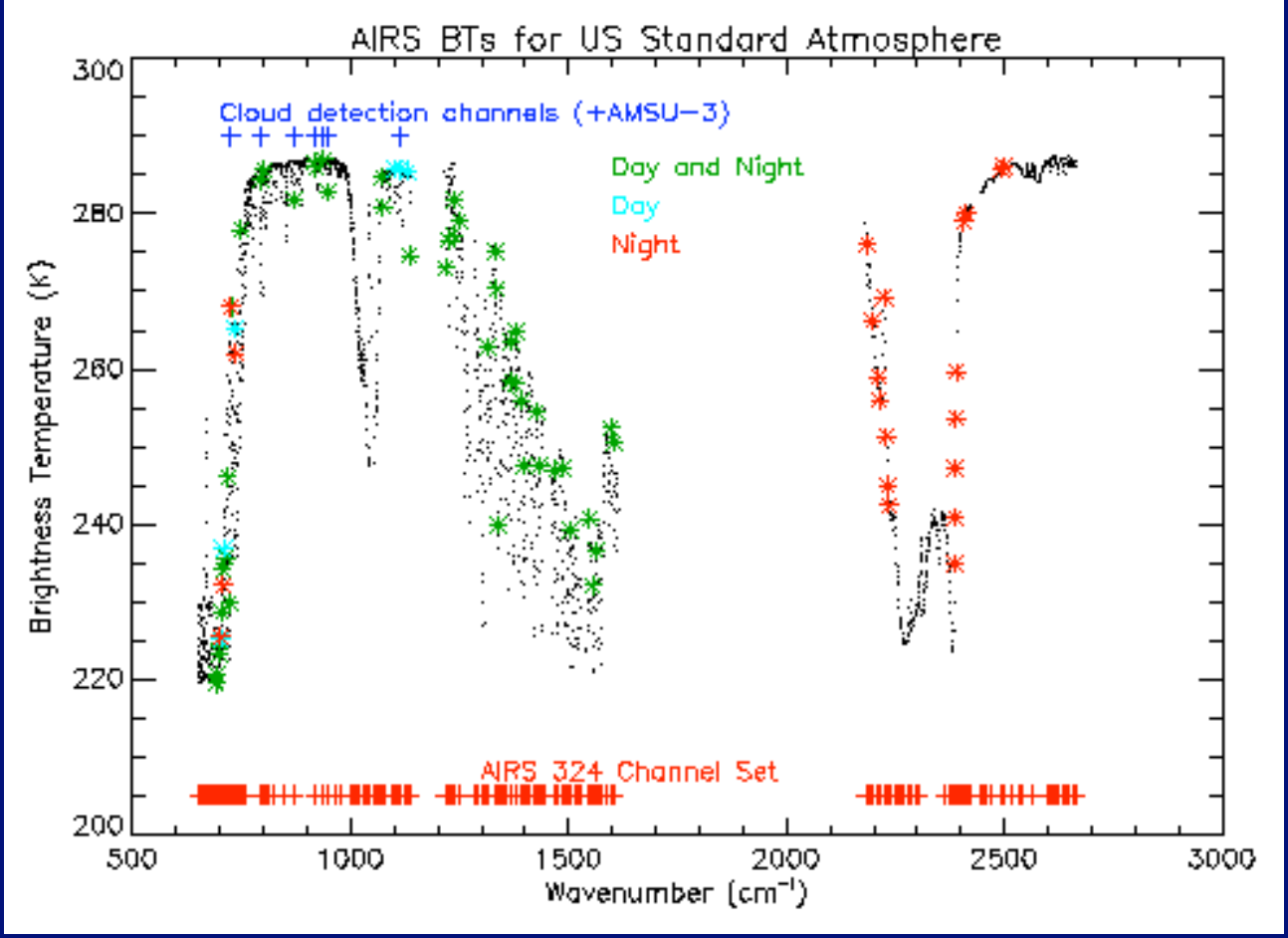
1D-Var Cost Distribution



No. of occurrences

1D-Var Cost Function Value

Channel Selection



- 324 AIRS channels supplied
- Assimilate a subset of 71 (day) or 86 (night)
- Choose those with highest impact on degrees of freedom for signal (Rodgers, 1996)

Initial AIRS Assimilation Trial

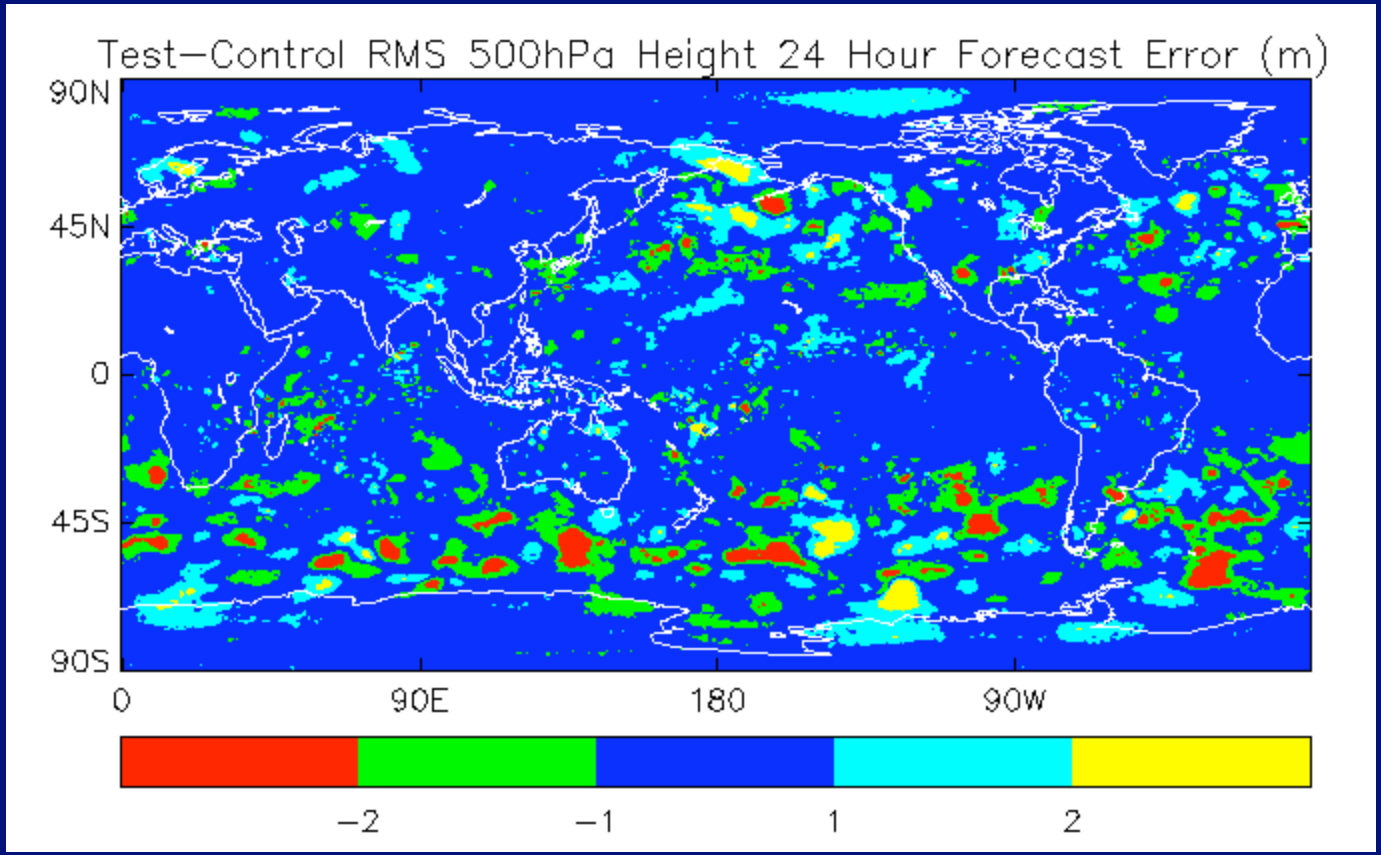
- 16th December 2002 - 13th January 2003
- Main AIRS trial run started in August 2003
  - Currently we have reached 5th January
- Headline verification score is NWP index
  - Here we also present rms forecast error for 500hPa height.

Change in Forecast Errors: 500hPa Height at 24 hours

-0.2%

-0.6%

-1.8%



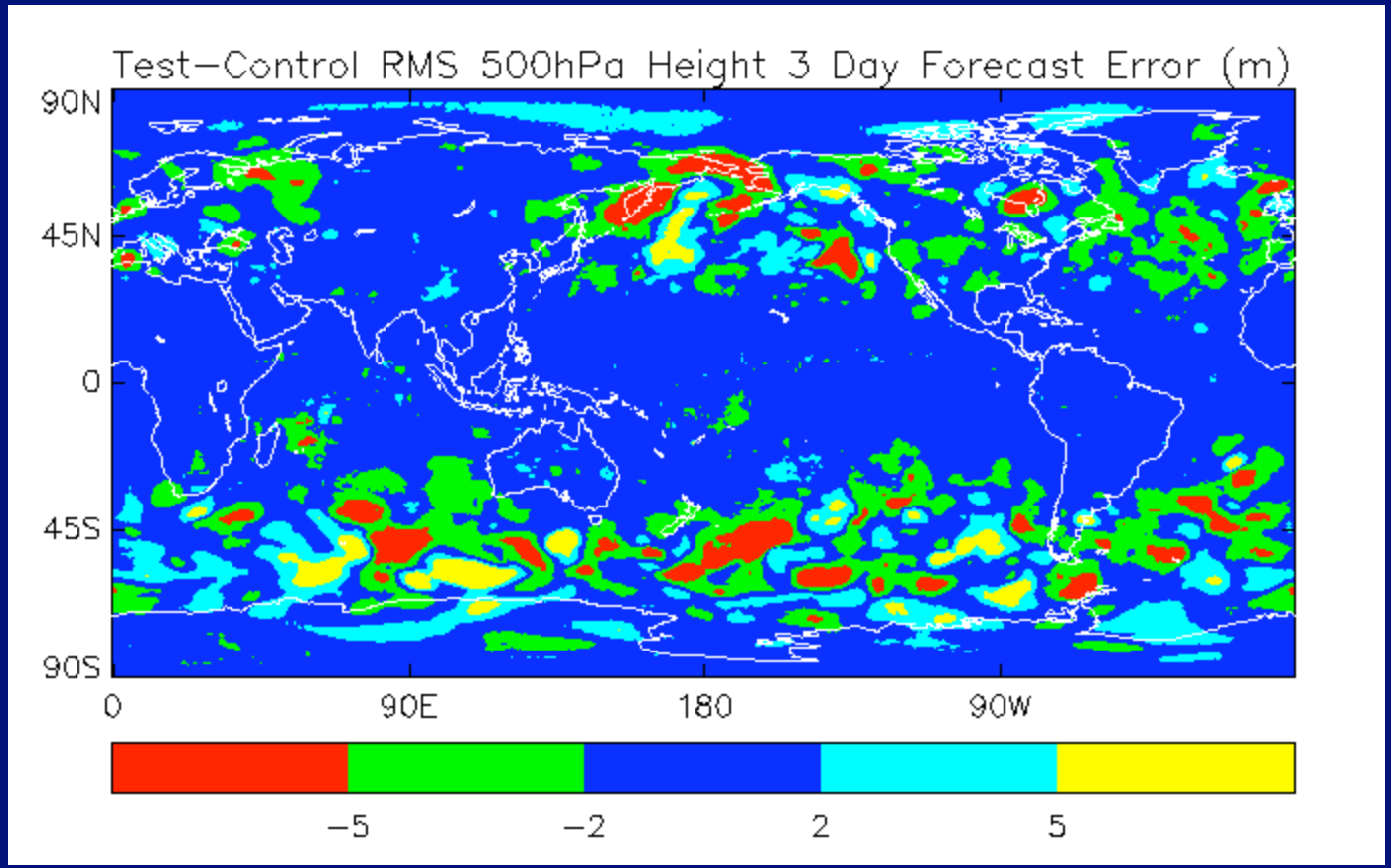
Met Office

Change in Forecast Errors: 500hPa Height at 72 hours

-2.0%

-1.0%

+0.3%



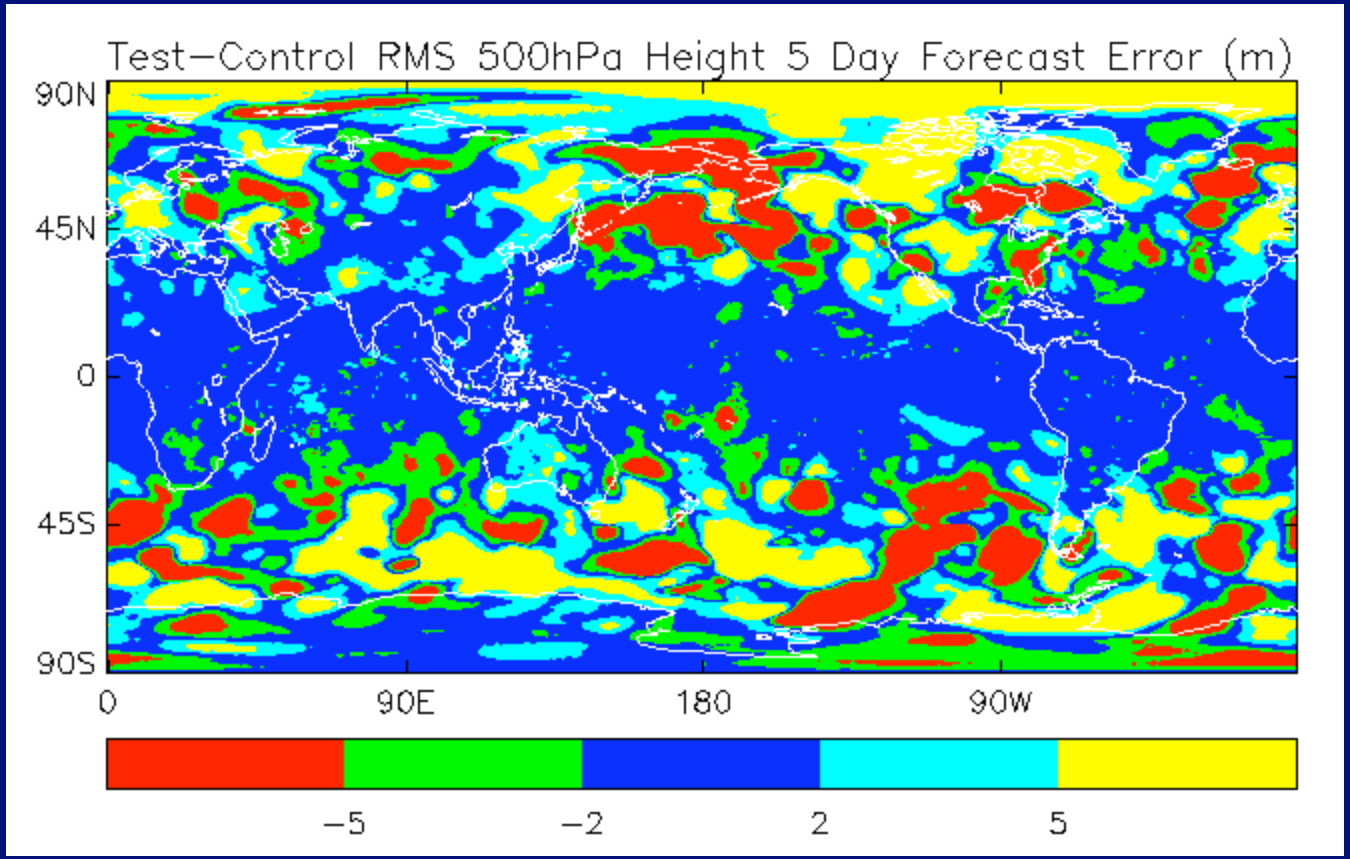
Met Office

Change in Forecast Errors: 500hPa Height at 120 hours

0.0%

-1.1%

-1.1%



Met Office

Trial Progress:
Verification vs Observations

Parameter Details				No of Values	Control Data			Test Data			Differences		
Area	Field Code	Fc Range	Wt	12Z	Fc RMS	Per RMS	Wted Skill	Fc RMS	Per RMS	Wted Skill	Fc RMS Diff (%)	Skill Diff	UnWted Diff
NH	PMSL	T+24	10	17	1.807	7.808	9.464	1.810	7.804	9.462	0.18	-0.00	-0.00
NH	PMSL	T+48	8	16	2.641	10.910	7.531	2.618	10.904	7.539	-0.87	0.01	0.00
NH	PMSL	T+72	6	15	4.143	11.539	5.226	4.093	11.537	5.245	-1.20	0.02	0.00
NH	PMSL	T+96	4	14	5.822	12.154	3.082	5.824	12.154	3.082	0.04	-0.00	-0.00
NH	PMSL	T+120	4	13	7.386	12.469	2.596	7.339	12.469	2.614	-0.64	0.02	0.00
NH	H500	T+24	6	17	15.630	73.249	5.727	15.593	73.255	5.728	-0.24	0.00	0.00
NH	H500	T+48	4	16	22.875	99.883	3.790	22.708	99.877	3.793	-0.73	0.00	0.00
NH	H500	T+72	2	15	34.848	107.238	1.789	34.414	107.228	1.794	-1.24	0.01	0.00
NH	W250	T+24	12	17	6.424	22.971	11.061	6.407	22.979	11.067	-0.26	0.01	0.00
Trop	W850	T+24	5	17	3.958	4.524	1.173	3.959	4.530	1.181	0.02	0.01	0.00
Trop	W850	T+48	3	16	4.338	5.567	1.178	4.334	5.573	1.186	-0.09	0.01	0.00
Trop	W850	T+72	2	15	4.632	5.988	0.803	4.599	5.993	0.822	-0.72	0.02	0.01
Trop	W250	T+24	6	17	6.201	9.536	3.463	6.098	9.527	3.542	-1.66	0.08	0.01
SH	PMSL	T+24	5	17	1.581	4.708	4.436	1.578	4.705	4.438	-0.23	0.00	0.00
SH	PMSL	T+48	4	16	2.056	6.603	3.612	2.050	6.599	3.614	-0.31	0.00	0.00
SH	PMSL	T+72	3	15	2.635	7.563	2.636	2.628	7.558	2.637	-0.26	0.00	0.00
SH	PMSL	T+96	2	14	3.325	8.226	1.673	3.359	8.219	1.666	1.03	-0.01	-0.00
SH	PMSL	T+120	2	13	4.194	8.333	1.493	4.148	8.330	1.504	-1.11	0.01	0.01
SH	H500	T+24	3	17	14.226	53.867	2.791	13.971	53.838	2.798	-1.80	0.01	0.00
SH	H500	T+48	2	16	18.173	75.676	1.885	18.013	75.638	1.887	-0.88	0.00	0.00
SH	H500	T+72	1	15	26.750	86.934	0.905	26.819	86.905	0.905	0.26	-0.00	-0.00
SH	W250	T+24	6	17	6.886	17.030	5.019	6.858	17.061	5.030	-0.41	0.01	0.00

NWP Index
up by 0.54%

Trial Progress:
Verification vs Analyses

Parameter Details				No of Values	Control Data			Test Data			Differences		
Area	Field Code	Fc Range	Wt	12Z	Fc RMS	Per RMS	Wted Skill	Fc RMS	Per RMS	Wted Skill	Fc RMS Diff (%)	Skill Diff	UnWted Diff
NH	PMSL	T+24	10	18	1.404	6.835	9.578	1.408	6.835	9.576	0.26	-0.00	-0.00
NH	PMSL	T+48	8	17	2.325	9.302	7.500	2.314	9.301	7.505	-0.49	0.00	0.00
NH	PMSL	T+72	6	16	3.595	10.171	5.250	3.530	10.171	5.277	-1.81	0.03	0.00
NH	PMSL	T+96	4	15	5.061	11.112	3.170	4.964	11.112	3.202	-1.92	0.03	0.01
NH	PMSL	T+120	4	14	6.319	11.814	2.856	6.273	11.815	2.872	-0.73	0.02	0.00
NH	H500	T+24	6	18	12.035	73.702	5.840	12.068	73.734	5.839	0.27	-0.00	-0.00
NH	H500	T+48	4	17	21.237	101.249	3.824	20.996	101.293	3.828	-1.14	0.00	0.00
NH	H500	T+72	2	16	32.606	111.153	1.828	31.962	111.161	1.835	-1.97	0.01	0.00
NH	W250	T+24	12	18	4.287	21.933	11.541	4.290	21.942	11.541	0.05	-0.00	-0.00
Trop	W850	T+24	5	18	2.025	3.380	3.205	2.016	3.381	3.221	-0.41	0.02	0.00
Trop	W850	T+48	3	17	2.708	4.556	1.941	2.686	4.550	1.955	-0.81	0.01	0.00
Trop	W850	T+72	2	16	3.159	5.071	1.224	3.125	5.066	1.239	-1.08	0.02	0.01
Trop	W250	T+24	6	18	3.593	7.856	4.745	3.575	7.803	4.741	-0.50	-0.00	-0.00
SH	PMSL	T+24	5	18	1.279	5.903	4.765	1.264	5.898	4.771	-1.22	0.01	0.00
SH	PMSL	T+48	4	17	2.181	7.853	3.691	2.161	7.845	3.696	-0.91	0.00	0.00
SH	PMSL	T+72	3	16	3.158	8.670	2.602	3.133	8.662	2.608	-0.80	0.01	0.00
SH	PMSL	T+96	2	15	4.174	9.276	1.595	4.156	9.265	1.597	-0.42	0.00	0.00
SH	PMSL	T+120	2	14	5.196	9.791	1.437	5.146	9.780	1.446	-0.97	0.01	0.00
SH	H500	T+24	3	18	12.482	66.148	2.893	12.331	66.039	2.895	-1.20	0.00	0.00
SH	H500	T+48	2	17	21.821	90.164	1.883	21.630	90.061	1.885	-0.88	0.00	0.00
SH	H500	T+72	1	16	32.088	101.209	0.899	31.886	101.119	0.901	-0.63	0.00	0.00
SH	W250	T+24	6	18	4.412	18.154	5.646	4.370	18.191	5.654	-0.96	0.01	0.00

NWP Index
up by 0.71%

Future Work

- Improve cloud detection
  - Revisit channel choice for cloud detection
  - Look into implementing PCA approach
  - AIRS visible imager data (during daytime)
- Continue investigation of bias correction
- Use of advanced sounder data over land
  - Start by using channels that do not see the surface
- Assimilation of cloudy infrared data
  - Use 1DVar step to try to infer cloud optical properties before assimilation

Conclusions

- Day-1 processing system in place
  - System is designed to be very conservative.
- Cloud detection system being investigated
  - Some tuning may be required
- Initial trial results show neutral to positive impact.
- We will run a second trial for July 2003 on our new NEC SX-6 supercomputer
  - should be much faster!
  - If also neutral or positive AIRS should be operational by March 2004.